

Energy  
efficient  
Restoration

# energieke restauratie

International  
Conference



**HanzeResearch**  
University of Applied Sciences

NoorderRuimte, Area Development





# Adaptive energy efficiency in historic buildings

By MAARTEN VIEVEEN (HANZE UNIVERSITY  
OF APPLIED SCIENCES, GRONINGEN)

## Abstract

**R**edeveloping sustainable historic buildings is about improving the usability (comfort, operating expenses by lowering energy costs) and preserving heritage qualities. In practice this means finding ways for energy efficient restoration is done on an ad hoc basis. The purpose of this study is to introduce a new generic approach towards energy efficient historic buildings, based on different approaches from the literature. This approach is tested by conducting three case studies. Data was gathered by doing historical research, research on the technical condition, owner preferences for using the building and effects of energy measures on energy consumption, investment costs and the heritage qualities.

The results of the case study projects suggested improvements for the generic approach, for example introducing a stakeholder analysis and making a classification in strategies for energy efficiency. The case studies also show that further research should be done on mechanisms that influence the potential for energy measures in historical buildings: what defines **tolerance for change** of historic buildings?

The generic approach for **adaptive energy efficiency** consists of a method to inventory values and interests that influence decision-making in the redevelopment process. This can help owners reach consensus with other stakeholders in the redevelopment process. It may provide insight in assumptions, stakeholder goals and limitations of the buildings characteristics.

## Introduction

Historic buildings exist in different sizes and types (dwellings, churches, farms, monasteries, castles, factories), but there is one thing they share: their heritage qualities. And although there is discussion about what these heritage qualities may be and how we can measure these qualities (meaning, authenticity, uniqueness) most owners and users of historic buildings, local residents and governmental organisations agree that these buildings should be preserved for future generations. By heritage policy, governmental organisations can protect historic buildings as monuments.

Actors that own historic buildings are primarily responsible for their preservation and they are faced with the daily running of the historic building such as the indoor climate and costs for maintenance and energy use. How can we improve the energy efficiency of historic buildings without lowering user comfort and without damaging heritage qualities? This paper focuses on an approach for the energy efficient restoration of historical buildings.

## The sustainable development of historic buildings

In the Netherlands sustainable development is becoming more accepted in the real estate and building industry sectors. What does this concept mean in the context of historic buildings? Sustainable development is often defined as ‘development which meets the needs of the present without compromising the ability of future generations to meet their own needs’ (WCDE, Brundtland 1987). Therefore sustainable development is about two aspects: durability and sustainability. Durability is about effects in the long term, for example lifecycle (effects over time) and flexibility (present and future needs). Sustainability is about the effects on our natural environment (planet), social impact (people) and economic impact (prosperity). Sustainable development in the construction industry in the Netherlands mainly focuses on health and safety issues on the one hand, and lowering CO<sub>2</sub> emissions (materials and energy efficiency) on the other.

From a heritage perspective, sustainable heritage is more about durability, for example preserving heritage qualities,

such as aesthetic qualities and authenticity (Nusselder et al 2008; RCE 201, 2011a/b, 2013a/b). Or as Van der Ven (2011, my translation) states: 'Sustainable and energy efficient monuments are about improving sustainability (effect on the environment), while simultaneously preserving as much heritage qualities as possible. Different instruments for measuring sustainable heritage have already been developed'.

Notwithstanding these instruments for sustainable monuments, there is no generic approach for adaptive energy efficiency in historic buildings as yet. Views concerning the acceptability of energy measures differ widely; what is acceptable from an environmental perspective can be totally unacceptable from a heritage perspective. Which energy measures can be taken without damaging the heritage qualities?

In this article different approaches for improving the energy efficiency of historic buildings are discussed. The generic approach adopted from literature was tested by conducting three case studies. Based on their results a generic approach is suggested that combines heritage preservation and the reduction of energy use in historic buildings.

### Theory: towards a generic approach

#### The Dutch tailor-made approach

Although in Dutch practice it is said that heritage protection is strict, the Dutch approach for heritage preservation can be defined as open since it is based on reaching consensus (Vieeen 2012). Based on the heritage qualities and preferences of the owners of historic buildings the stakeholders involved in the redevelopment process develop a plan that suits the unique situation. Since every situation is different (specific building characteristics, interest of stakeholders, context) solutions cannot be defined beforehand and should be tailor-made. Therefore a generic approach should focus on guiding the process of developing a tailor-made solution for the energy efficient restoration of historic buildings and it should be flexible so as to allow a variety of solutions for each unique situation.

In the literature different specific approaches are described on how to reduce energy consumption, how adaptive reuse can take place, and how the sustainability of heritage can be measured. By integrating these approaches a generic approach for taking energy measures in historic buildings is suggested. The discussed approaches are the Trias Energetica by Lysen (1996), Adaptive reuse by Nelissen et al. (1999) and Sustainable Monuments by Nusselder et al. (2008).

#### The Trias Energetica

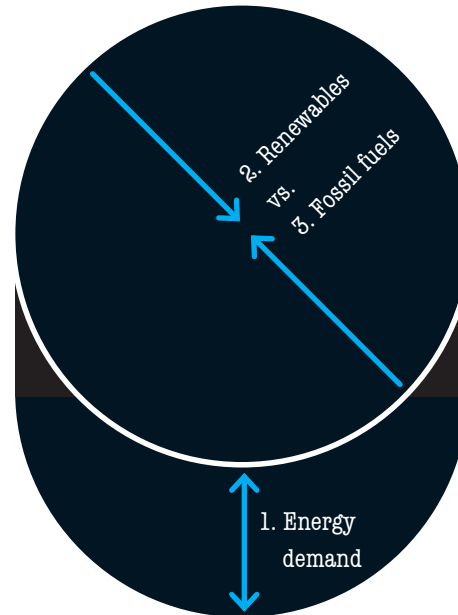
In his paper, Erik Lysen (1996) proposed an approach that combined three strategies towards a sustainable energy supply. The first strategy is increasing the energy efficiency of the building permanently. Energy consumption is reduced by preventing heat loss in the buildings, for example by draft-proofing seals and insulation.

The second strategy is the use of renewables to supply energy demand. For example by reusing thermal energy and using energy from the soil, sun, wind etc.

In an ideal situation a building can supply its own (net) energy demand and a CO-neutral building may be possible. When this is not the case, the remaining energy demand can be supported with relatively clean or efficient fossil fuel systems, for example by implementing a highly efficient heating installation.

To summarise, the Trias Energetica is about: a) the energy demand, strategy 1, and; b) the energy source, strategy 2 and 3 (see figure 1).

Figure 1: Trias Energetica (inspired by Lysen, 1996)



#### Relevance for the approach adaptive energy efficiency

The Trias Energetica approach is useful to become more aware of energy inefficiency (to explain what causes current energy demand) and the impact of the energy source on the environment.

#### Adaptive reuse

Adaptive reuse of historic buildings can be described as using the building for new activities without damaging essential heritage qualities of the building (Nelissen et al., 1999). Therefore adaptive reuse may implicate the loss of functionality (practical use, thermal comfort, relatively higher operating expenses), since certain modifications may not be acceptable.

In his book *Reuse of Large Listed Heritage Buildings: a Challenge!* Nelissen et al. (1999) introduce the KUN model, containing ten (iterative) steps for the adaptive reuse process (figure 2):

- Interpret vacancy: why did the building become vacant?
- Reuse initiative: an inspiring vision by developers and strategic stakeholders.
- Reuse strategy: what are the main goals and how can they be reached?
- Characteristics of the building and the nearby area: What is the size of the building? What is the spatial layout of the area? What heritage qualities should be preserved?
- Designing and feasibility: Designing a plan for reuse and researching its financial feasibility.
- Financing: what are the effects of the budget and external financing (conditions) for the design?

- Reuse plan: develop the 'final design' for reuse.
- Building permit: decision making by the authorised government.
- Implementation: realising the plan for reuse.
- Real Estate Management (REM): use the building, maintenance etc.

1. Interpret vacancy
2. Reuse initiative
3. Reuse strategy
4. Building and nearby area
5. Design and feasibility
  6. Financing
  7. Reuse plan
  8. Building license
  9. Implement
  10. REM

**Figure 2**, KUN-model for adaptive reuse (inspired by Nelissen et al., 1999)

In the first steps (1-3) the process focuses on explaining why change is necessary, and on determining the scope of the project. In the fourth step the characteristics of the building and nearby area are inventoried: size, materials, (physical) environment such as infrastructure, and accessibility. Explaining what causes the current energy consumption may also be embedded in this step. This step can also be about more subjective data, for example the valuation of historic quality by different stakeholders, or the perception of thermal comfort by users. Exploring potential energy measures can be embedded in the fifth step, when the plan (such as the design) and financial and technical feasibility studies take place. Because this article focuses on developing a plan for energy efficiency the other steps (6-10) are not taken into account here. Still it is wise to consider the tenth step – REM –, since energy management (systems) can influence energy consumption.

### Relevance for the approach adaptive energy efficiency

Several steps of the KUN-model are relevant for the generic approach to adaptive energy efficiency:

- Positioning the urgency for reducing energy consumption in a wider context. What are current user complaints and what are the demands for the long term (use, expenses, thermal comfort etc.);
- Inventory of heritage qualities of the building (what is the tolerance for change);
- Analyze what causes the current energy consumption, related to the building, installations and use (activities and energy management).

### The DuMo score for Sustainable monuments

An important step towards the sustainable development of historic buildings was taken by Nusselder et al.(2008). In the

Manual for Sustainable Monuments he suggests an integration of two methods for indexing Sustainability (Duurzaamheid) and Heritage qualities (Monumenten). Furthermore, Nusselder et al. describe specific strategies for taking sustainable measures in historic buildings.

### The Sustainability index

The Sustainability Index is based on three separate themes: energy, materials and water.

### Heritage quality index

Heritage valuation is used to make an inventory on what can be defined as heritage qualities that make a historic building unique. The degree in which building (parts) should be preserved are also defined as the tolerance for change (in Dutch: 'aanraakbaarheid'). Insight in the heritage qualities indicate different categories on the tolerance for change (Nusselder et al. 2008; 19-21):

A	museum-documentary	mark 2,0 - 3,0;
B	museum-functional	mark 1,5 - 2,0;
C	museum-flexible	mark 1,0 - 1,5;
X	characteristic, not listed	mark 1,0 - 3,0.

Nusselder et al. (2008) expressly use the word indicate because a valuation, although described by criteria, is a subjective process and therefore marks should not be used for calculations (Nusselder et al. 2008, 23).

### DuMo score

Combining the Sustainability Index and the Heritage quality Index results in the DuMo score of a historic building. This score explains how sustainable the historic building is, taking into account heritage qualities (Nusselder et al. 2008; 41-42). By using this method a building with highly valued heritage qualities and low sustainability performance can have the same DuMo score as a historic building with lowly valued heritage qualities and a high sustainability performance.

### Design strategies for sustainable monuments

Nusselder et al. (2008; 43-131) also describe twenty strategies that can be used in the sustainable development of historic buildings. For our approach to adaptive energy efficiency in historic buildings the following strategies may be relevant:

- 5) Adaptive comfort: Preservation supersedes user comfort. Accept that high performance demands for user comfort may not be achieved in a historic building [2008: 60-68].
- 8) Adjacent unheated spaces: Spaces as (thermal) buffers between the indoor and outdoor climate (for example, the 'box-in-a-box' concept) [2008:78-82].
- 9) New installations: Existing (spaces for) installations for heating, cooling and ventilation can be upgraded or reused to reduce energy consumption. Only replace or add new installations if they are a lot more energy efficient [2008: 85-90].
- 10) Insulation: By applying draft-proofing seals when restoring building components. Also, insulation may involve damage



- risks for authentic materials (moisture, cracks) [2008: 90-95].
- 13) Using spaces with high ceilings: Applying new suspended ceilings for installations and insulation; creating extra floors [2008:104-106].
- 16) User information: For (improving) proper use (prevent undesirable indoor climate) and the reduction of operating expenses (energy and maintenance) [2008: 116-118].

### Relevance for the approach adaptive energy efficiency

The DuMo approach supplies a basis for reaching a consensus in weighing potential sustainable measures and heritage. From the DuMo approach we take the following topics for our generic approach for adaptive energy efficiency:

- Inventory and weighing different visions, ambitions and valuations (how to preserve, the demands for energy efficiency);
- Inventory of heritage qualities of the building (components), and;
- Determining potential sustainable measures, and specific energy measures. What are the buildings' characteristics and what could be future user demands?

### Methodology

In this chapter the methodology is discussed. Firstly the steps of our generic approach are presented. Secondly the specific techniques used for data collection are summarized. Finally the selected case studies are discussed.

### Generic approach towards energy efficient historic buildings

Based on the approaches Trias Energetica, Adaptive reuse and Sustainable Monuments, a generic approach is suggested consisting of six steps:

- *Inventory of heritage qualities*: an inventory of stories, specific structures (layout) and building components, detailing, interior elements etc. that contribute to the heritage quality of the historic building.
- *Inventory of the technical condition*: good maintenance, or in some situations the extent of decay, may have a great influence on the tolerance for change and thus the budget for restoration and feasibility of energy measures.
- *Explain current energy consumption*: for example the characteristics of the building (size, materials, leaks), installations (systems, efficiency, control systems), and the use of buildings and installations (human behaviour and energy management).
- *Understand the current user complaints*: specific preferences of the user which need to be solved in the new situation, for example cold draft, low thermal comfort, image of the organisation or large open spaces.
- *Inventory future user demands*: focused on end goals of the stakeholders. The end goal may be derived from current user complaints, an idealistic drive, (governmental) policy, etc.
- *Explore potential energy interventions*: a study on the technical (buildings physics, energy consumption, investment) feasibility of energy measures such as insulating, heating systems or generating sustainable energy.

### Selection of case study projects

To test the generic approach three case studies were conducted. The case studies were selected by participants from the research group *Sustainable development of historic buildings* during the research project *Energieke Restauratie* (Energy efficient Restoration). Because of the geographical focus of the research project, all cases were in the north of the Netherlands (Figure 3):

- *De Dongeradelen*: a vacant former dairy factory in a rural area Morra / Lioessens – not a listed building;
- *Free*: a vacant former strawboard factory in the village of Oude Pekela – not a listed building;
- *Der Aa church*: a former church used for exhibitions, events and concerts in the inner city of Groningen – listed building (of national importance).

The selected case studies were conducted by graduation candidates (B.Sc.) in (building) engineering, human technology and real estate management of the Hanze University of Applied Sciences Groningen.



Figure 3, locations of the case studies

## Data collection

In line with our suggested approach we collected data using the following procedure:

- Inventory of heritage qualities by desk research: heritage value assessment; and research in the field;
- Inventory of the technical conditions by observation research in the field;
- Explaining current energy consumption by desk research and research in the field: such as data on size of the building, intensity of activities, energy consumption/expenses; calculations on energy performance);
- Understanding the current user complains and doing an inventory on future user demands by conducting (an) interview(s) and organising discussion meetings with stakeholders, and;
- Exploring potential energy interventions by calculations on investment costs and energy performance, weighting different values (heritage qualities, energy performance, usability, thermal comfort), and by organizing discussion meetings with stakeholders.

## Results

In this chapter the results of the case study projects are described. Firstly the former dairy factory De Dongeradelen is described, secondly the former strawboard factory Free and thirdly the Der Aa church. The structure of the paragraphs relate to the steps for the generic approach for Adaptive Energy Efficiency in historic buildings as described in the former paragraphs.

### De Dongeradelen, former dairy factory

This paragraph is based on the research project conducted by Van der Leek, Zijlstra, Smit and Sarsam (2012).

### Inventory of heritage qualities

Former dairy factory De Dongeradelen is not listed as a monument although it is one of the ten last remaining dairy factories in the province of Fryslân. In 1915 the dairy factory was constructed by a corporation of 177 members. The factory consisted of a directors villa (not part of the case study project) one office and four factory buildings for the production of milk, butter and cheese (Figure 4).



Figure 4, postcard from the dairy factory in 1916

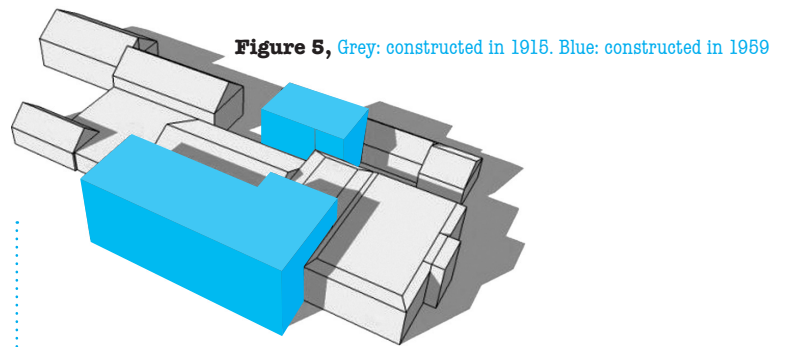


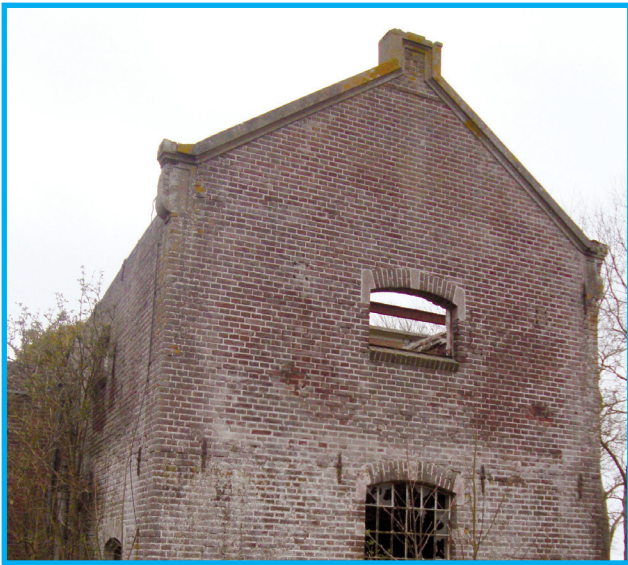
Figure 5, Grey: constructed in 1915. Blue: constructed in 1959

Since the number of members of the corporation increased fast to 400 members in 1958, more space was required and the factory was extended with a lab and an expedition room in 1959 (Figure 5). After merging with other dairy factories, the production process was limited to the production of exclusive cheese.

In 1973 the factory was closed and sold to another owner, which reused the factory as a riding school. The former factory was sold again in 1980 and during the building process a lot of interior elements were removed. First the former factory was used for storing agricultural machines, and a petrol station was established on the west side of the factory lot. Later on, in the 1990s, part of the factory was temporarily in use for residential purposes, until the last residents left in 2004. After that the building was sold and left vacant.

Buildings constructed in 1915 were based on a steel construction with (red) brick walls. The brick walls were provided with steel windows and ornaments on the gable. The roof is constructed with wooden beams covered with (dark brown, black and beige) roof tiles. When looking at the physical elements the gable (Figure 6), steel wall anchors and steels windows are characteristic for the construction period. Characteristic details are the façade of the factory with brick detailing and the factory name. Extensions constructed in 1959 were built out of (grey) concrete prefabricated panels (Figure 8) in a steel construction. The roof was covered with bitumen. Columns were constructed out of reinforced concrete. The walls were provided with (red and white painted) wooden windows. On the inside spaces were covered with (white) plaster and (yellow and black) ceramic tiles. Most of the interior elements are gone, with exception of the ceramic tiles (on the walls) and the basements of the removed milk tanks (Figure 7).





**Figure 6,** gable in the brick wall of a 1915 building



**Figure 9,** collapsed floors of the buildings from 1915



**Figure 7,** basement of the milk tanks



**Figure 8,** damaged concrete panels of the buildings from 1959

### **Inventory of the technical condition**

Since the buildings were not maintained in past decade, much damage was found. All of the buildings are in a bad technical condition, or even dangerous to enter. Most of the roofs of the old production buildings from 1915 had collapsed (**Figure 9**) and therefore the walls could be unstable. Also, some of the concrete panels from the buildings from 1959 fell down. Entering and walking around these parts of the buildings can be dangerous.

All building(s) (parts) suffered damage in the last decades. Wooden components started to rot (roofs, window frames), rust infected metal (gutters, cast iron drainpipes and window frames), vegetation appeared on roofs and walls, and cracks in the brick walls.

### **Explain current energy consumption**

Since the building is vacant, the current energy consumption is zero. The only functional installations are the lighting in the part of the buildings that were in use as residence until 2004.

### **Understand the current user complaints**

Since the building is vacant, there are no users with complaints. But the owner of the former factory would like to make a feasible investment. During a workshop with representatives of the villages of Morra and Lioessens, the municipality and participants of the research group, it was stated that vacancy was undesirable: the damaged buildings and fences have a negative impact on the image of the picturesque village.

### **Inventory future user demands**

One of the outcomes of the workshop was the advice to focus on reuse that anticipates the regional economy, such as tourism: the historic inner city of Dokkum, a holiday park, and national park Lauwersmeer are only a ten minute drive away. Another new initiative is a rail-cycling route adjacent to the former dairy factory. Therefore reusing the historic buildings as a wellness centre was suggested (**Figure 10, 11**). The owner of the building was enthusiastic: 'any financial feasible idea for (re)developing the land and former factory has my interest.' Also, high energy efficiency was preferred to reduce daily operating expenses.





**Figure 10,** building lot and the rail-cycling route



**Figure 11,** renovated dairy factory



### Explore potential energy interventions

It was suggested to use the buildings constructed in 1915 for the wellness baths. The brick wall will be stabilised with a new inner glazed steel (box-in-a-box) construction (**Figure 12, 13**). The buildings constructed in 1959 will be used as dressing rooms, a sauna square (where the saunas are placed on top of the basements of the milk tanks, (**Figure 14**), massage rooms and café. The connecting space will be replaced by demolished and rebuilt since it is in a bad technical condition.

The walls and roofs constructed in 1959 and newly built spaces will be provided with high quality insulation. The building will be provided with a floor heating system. Also, the warmth of the wellness baths will be reused by a heat recovery system for the heating system. The lighting will be provided by a LED light system. Warm water for the baths will be provided by a wood pellet heating system and photovoltaic panels on the flat roofs for electricity. Altogether it is estimated that the energy demand in a year will be 3.630 m<sup>3</sup> of gas and 32.197 kWh of electricity, resulting in an energy label A++.

### Free, former strawboard factory

This paragraph is based on the case study research conducted by Calvillo Rubio, Hoek, Kempenaar, Ochando Fons, Van der Vecht (2012).

### Inventory of heritage qualities

The former Veenkoloniën ("Peat Colonies") in the province of Groningen have a rich industrial past. The strawboard industry had flourished since the 19th century and attracted many other industries. Strawboard products were exported all over North-West Europe and even to the United States of America. In those days the village of Oude Pekela housed nine strawboard factories of which four still exist (DBF 2011). One of them was strawboard factory Free in the north of the village, which was constructed in 1903 in an industrial (expressionistic brick

**Figure 12,** the glazed wellness baths

**Figure 13,** wellness baths

**Figure 14,** the sauna square





**Figure 15,** Free at the beginning of the 20th century

**Figure 16,** steam engine room, 1929



**Figure 17,** adjacent former steam boiler room

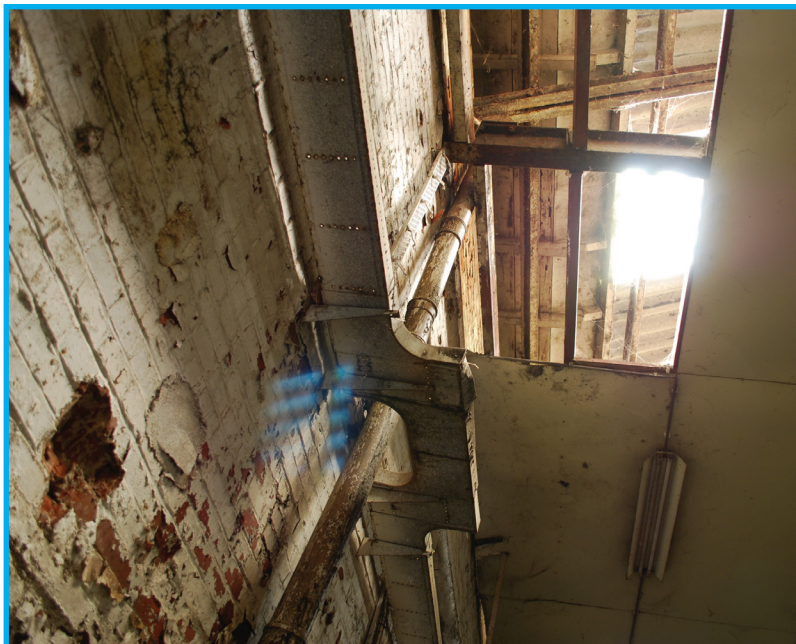


architecture) style. Characteristics are the symmetric facades with expressionistic detailing in the top front facade (Figure 15), partly steel window frames, the large doors and the factory chimney.

In 1929 the factory was extended and a steam engine installed. The steam engine room is tiled with glazed yellow and black tiles (Figure 16). The casing and front panels of the operating system are still intact although the copper wiring was stolen. The adjacent former steam boiler room at the corner of the complex was renewed in 1969 (Figure 17), the involved stakeholders valued this part of the buildings with lower/no heritage qualities.

Nowadays the building is owned by HempFlax, which uses the historic buildings as a depot for surplus material. Today the steam engine room is largely authentic (original interior) and the depot rooms have been cleaned. Besides one strawboard production line (Figure 18) and the steam engine, only the large open spaces remind of the production process.





^ **Figure 18**, old strawboard production line

< **Figure 19**, leakage also caused other (serious) damage to the building

> **Figure 20**, damage to the brick walls

### Inventory of the technical condition

Since the building became vacant, several machines have been removed. The building and its heritage qualities were damaged over time, also by vandalism. For example, the copper wiring and water drains were stolen which also caused damage to the roofing. To prevent further vandalism wooden panels were placed in front of the windows. The roof was repaired to prevent further damage.

Some serious damage has emerged to a) the (asbestos) ceilings and roofs (leakage by moisture and vandalism); b) cracks in the walls related to soil failure that effected the foundation; c) the factory chimney was repaired with steel bands which no longer work effectively; d) window frames and the glass windows were effected by moisture and vandalism and; e) old electricity wiring (**figure 19**).



Also other elements suffered some damage, for example rusted steel beams, erosion of bricks (**Figure 20**), degraded sewer system, broken (glazed) tiles on the floor and walls, and damaged plaster on the inside and outside of the building.

### Explain current energy consumption

Since the building is vacant, the current energy consumption is zero. Only the lighting is incidentally used.

### Understand the current user complaints

Although the factory is not actively used, HempFlax still wants to invest in the historic buildings. Not for their production line, but to improve the image of the company. The boarded windows and lack of activity attracts vandals and other uninvited guests. The municipality of Oude Pekela was enthusiastic about the intention to reuse the historic building because of the possible contribution to the local cultural identity, even though the buildings are not listed.

### Inventory future user demands

The initiative for reuse was taken by the 'Foundation Steam Engine Free and Co' in 1989. Their objective was to preserve, restore and bring the steam engine into operation (DBF, 2011). During the period 2010 to 2013 different studies have been conducted for the reuse of the historic buildings. This paper only focuses on the plan developed in 2012. The studies after the presented case study on energy efficient restoration in this paper, are about financial feasibility, restoration concept and a local (re)development vision on heritage tourism and entrepreneurship in Oude Pekela.

In a first exploratory feasibility study it was concluded that reusing the former factory as a museum may be possible, but would be difficult from an economic perspective. The local context (personnel, volunteers) and the presence of similar museums in the region should be taken into account. It was recommended that the financial risk of the investment should be spread by a phased implementation (DBF 2011).

After this report HempFlax was involved more intensively. The initiative for reuse might be strengthened by investing in a representative meeting-cum-showroom. The study also suggested a high ambition on sustainable building and energy efficiency. Since the historic buildings add value to the museums' and companies' image adaptive reuse was one of the major ambitions.

### Explore potential energy interventions

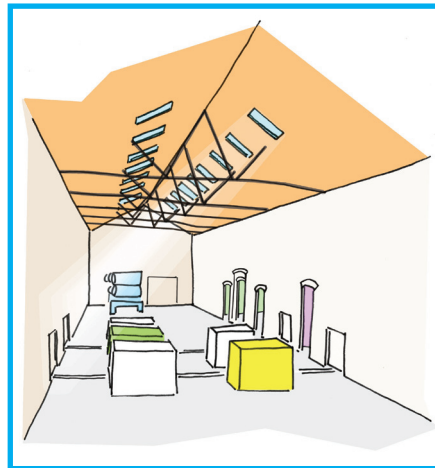
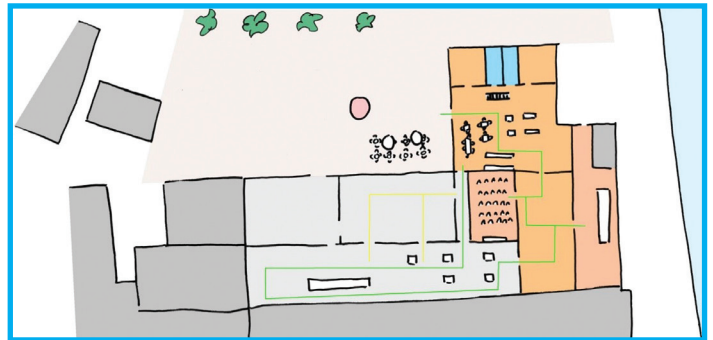
The developed plan suggested to use the route of the production line and heritage qualities as a basis for the layout of the former factory. The museum annex showroom/meeting room (**Figure 21**) can be entered from a central square into the former steam boiler room (**Figure 22**). Here visitors can buy tickets, merchandise and visit the restaurant.

The next part of the route leads to the oldest rooms, the original and 'current' engine room, which will be restored to their original state of 1903 and 1929. The building and machines will be the most important collection items.

When moving further on people enter the former strawboard production line rooms. Here the history of the strawboard industry can be exhibited, but also art of local artists (**Figure 23**). Before entering the former steam boiler room again, visitors may watch a movie in the small theatre.

The extent to which energy efficiency and thermal comfort is provided is based on the heritage qualities and technical condition of the spaces.

Because of the damage to the roofs and foundation it was suggested to provide the roofs with insulation and solar panels and to provide the floor with insulation and a floor heating system.

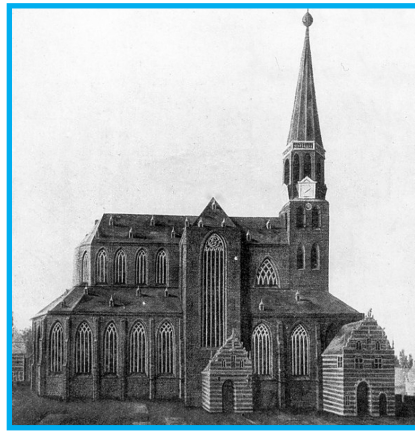
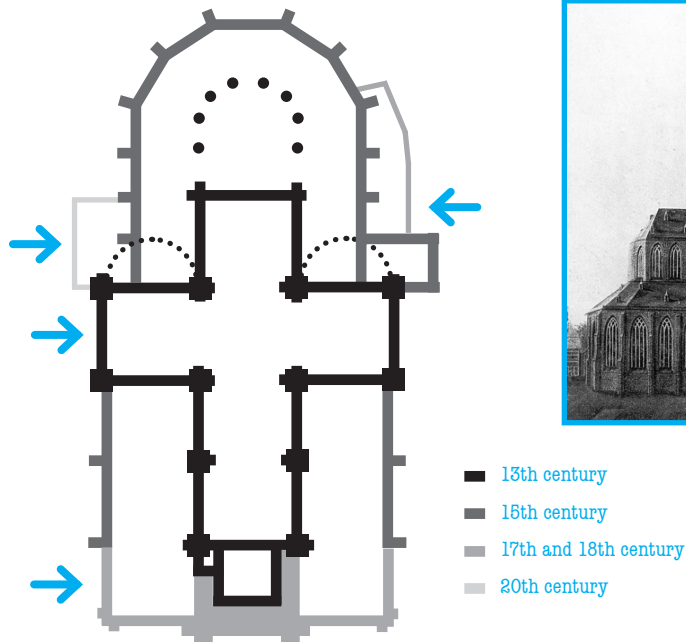


**Figure 21,** route of the museum

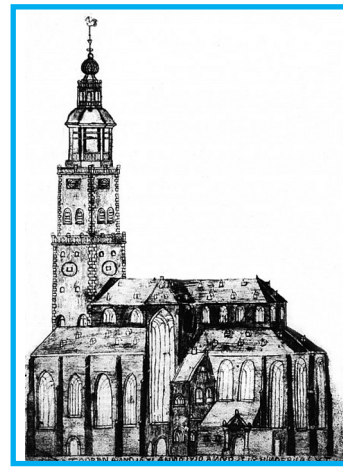
**Figure 22,** reception, café and showroom/meeting room in the former steam boiler room

**Figure 23,** exhibition room in the former strawboard production line rooms

**Figure 24, Der Aa church, about its history**



Tower 17th century



Tower 18th century

The original steam engine room will be restored, taking the above measures into account. The spaces which housed the straw board production line and the steam boiler will be insulated on the inner side of the brick walls. Since the former steam boiler room was not valued with high heritage qualities, architectural interventions were suggested by placing large glazed windows in the facades and roofs.

Energy is provided by solar panels (thermal and electric) and a biomass boiler using a waste product from the production process at HempFlax. The lighting will be provided by a LED light system. By implementing these systems the historic factory should be energy self-sufficient. A consequence is a bigger investment with a Return of Investment (RoI) in five or ten years taking into account the current energy prices.

#### ‘Der Aa’ church

This paragraph is based on the case study research conducted by Roffel and Glas (2012).

#### Inventory of heritage qualities

In the 12th century sailors and merchants built a chapel on the banks of the Aa, a river in Groningen. In 1246 the chapel was elevated into a Church, devoted to ‘Our Lady of the Aa’, which explains the name Der Aa church. In the 15th century (1425-1465) the church was changed into a Gothic basilica. During the reformation in the 16th century a lot of interior elements were lost and the church became used by the Protestants. After rebuilding the collapsed tower (and organ) in 1790, the exterior of the Der Aa church remained the same (Figure 24 and 25).

The most recent changes took place during the restoration of 1987 (in 2006 the interior was restored). In 1987 the Foundation for Old Churches in the province of Groningen became the new owner and reused the building for (cultural) events and parties. During the restoration of 1987 the glass wall between the choir and nave was removed and an air heating system

**Figure 25, exterior of the Der Aa church**



was installed. Nowadays the Foundation Der Aa Church owns the church and the Foundation Extraordinary Locations Groningen (BLG) is responsible for the use and operating expenses of the church.

Important heritage qualities are related to the Gothic architecture of the building with vertical emphasis (Figure 26) and use of light by the stained glass windows. Since the stained glass





- << **Figure 26**, choir with vertical emphasis, pews for the rich and murals
- < **Figure 27**, painted clustered columns of the stone vaults
- ✓ **Figure 28**, nave with platform and Schnitger organ
- ✓ **Figure 29**, separation of the choir and nave, and the glass wall before 1987



windows were renewed in 1987 the local heritage agency is open to changes to the glass windows. Important characteristic components are the masonry vaults (**Figure 27**), clustered columns, murals and interior elements such as the pews for the rich, the pulpit and the Schnitger organ, which itself is listed as a monument (**Figure 28**).

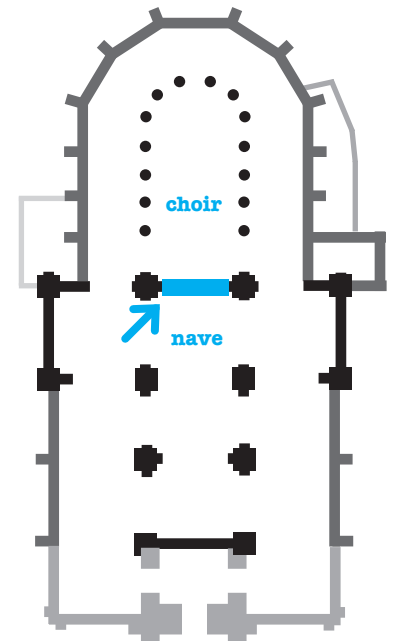
### Inventory of the technical condition

The Der Aa church is in good technical condition and regularly maintained. Two remarks can be made: a) some glass plates in the stained glass windows are broken, and b) the heating system is out-dated (it was installed in 1987 with an estimated lifespan of about 15 years).

### Explain current energy consumption

The Der Aa church is used for (cultural) events and parties. In 2011 the activities consisted of: weddings (1%), diners (3%), parties and receptions (7%), concerts and theatre (18%), and exhibitions fairs (71%). The average energy consumption between 2009 and 2011 was over 39.300 kWh and 36.000 m<sup>3</sup> of gas. BLG explained that the fluctuation in energy consumption over the years was caused by the amount and different types of activities (and audio-visual facilities) and different outdoor temperatures over the years. An interesting finding was that in 2011, the choir (volume about 8.640 m<sup>3</sup>) and nave (volume about 14.780 m<sup>3</sup>) were used together for 44% of the time and 56% separately, while the whole church was heated (volume about 23.420 m<sup>3</sup>). See also **Figure 29**.

The energy consumption is influenced by different factors, such as: a) a large volume of air which needs to be heated; b) high thermal comfort standards, and; c) low thermal resistance of windows and entrances. Also, it was found that the temperature underneath and above the masonry vaults was high, or even higher than the temperature at the ground floor level.



### Understand the current user complaints

The current energy costs have a large impact on healthy operating expenses. Also, clients sometimes complain about cold and cold draft. Even during summer, when the difference between indoor and outdoor temperature is relatively high, the church is heated to raise thermal comfort of clients.

### Inventory future user demands

The case study project was started to find out how energy costs may be reduced. Also, two other ambitions were taken into account: I) preserving the heritage qualities: they provide an ambiance that attracts clients; physical damage is unacceptable, especially to the listed organ, and II) improving thermal comfort for clients.

### Explore potential energy interventions

Because of the highly valued heritage qualities and ambitions the stakeholders involved suggested a brainstorm session with experts on possible energy measures. During this session energy measures were suggested, related to a) behaviour and energy management; b) the layout and volume of spaces; c) raising comfort; d) the heating system, and e) using energy that is available from the nearby area. Energy consumption in the new plan was modelled and simulated with VABI Elements. The results show that a lot of heat was lost through the masonry vaults, windows, heating system and the old outer walls above the vaults in the aisles. Based on the simulation, the following reduction of energy consumption for applying separate energy measures was found:

- Renew the heating system (63%)
- Apply a ventilation system with a BaOpt control system (47%)
- Insulate the masonry vaults (26%)
- Add a floor heating system (21%)
- Separate of the choir and nave (18%)
- Insulate the stained glass windows (8%)
- Insulate the former outer walls (3%)

Based on the risk of damaging heritage qualities it was recommended that the following measures would not be advisable: insulate the masonry vaults and former outer wall (thermal pressure on the construction of the vault and wooden beams), floor heating (damaging tombstones in the implementation phase).

Investment costs advised against the following measures: insulation of the stained glass windows and separation of the choir and nave.

Renewing the heating system and introducing the BaOpt system were seen as potential measures. However, this system requires an air-tight building, which was outside the scope of our research.

### Conclusions: a generic approach for adaptive energy efficiency

Our generic approach for energy efficient restoration contained the following steps:

- Inventory of heritage qualities
- Inventory of the technical condition
- Explain current energy consumption
- Understand the current user complaints
- Inventory future user demands
- Exploring potential energy interventions

Although these steps were very useful in providing important data in finding potential energy measures, the case studies showed that during the process three main topics can be distinguished related to the questions: 1) what causes current energy consumption? 2) What are the preferences of stakeholders? And 3) what could be potential energy measures for this particular situation?

The case of the Der Aa church shows that a thorough analysis of the use of the building and building physics may help to find innovative energy measures.

The *tolerance for change* of the historic building was an important factor towards the acceptance of energy measures in the case study projects. Therefore we suggest to categorize energy measures by the impact they have on heritage qualities.

To summarize, the following steps for a generic approach on *adaptive energy efficiency* are suggested:

- Explain the current energy consumption
- Building physics
- Technical conditions
- Use of the building (activities, behaviour, management)
- Inventory of different values
- Owners preferences
- Heritage qualities
- Interests of stakeholders
- Explore the support for energy measures in different strategies
- Human behaviour and management: improving functionality and thermal comfort;
- (minor) modifications: low impact on heritage qualities
- (major) interventions: high impact on heritage qualities
- Energy in the nearby area: generate (at others property) and exchange energy.

In this paper a generic approach for adaptive energy efficiency in historic buildings is suggested. However, some remarks need to be made. The conducted case studies were empirical studies to test if the approach could be improved.

The approach for adaptive energy efficient in historic buildings is developed for all types of historic buildings, all kinds of uses, regardless their technical condition. However, it may be possible that specific strategies only apply in specific situations. Before focusing on the buildings type, understanding these factors can be relevant in finding innovative solutions for energy efficiency.

The findings suggest that tolerance for change has a great influence on energy measures which might be accepted. But it still is unclear how to define tolerance for change. Based on the case studies the following questions could help to get a better understanding of tolerance for change:

- the involved stakeholders: which actors are involved in the decision making process and what are their interests? The stakeholders should reach a consensus so that the historic building can be passed on to future generations;
- the heritage paradigm: why are certain changes (modifications, interventions, transformation) accepted? This also has to do with current restoration philosophy, which may change over time: restore as was build, rebuild as it was, show all traces of construction, build with contrasts;
- the buildings characteristics: what are qualities of the historic building? Besides heritage qualities, it is also about the technical condition, functionality (size, facilities), thermal comfort and accessibility (location, route) and last but not least user valuation.



## References

Abrahamse, W., Steg, L., Vlek, V., Rothengatter, R. (2005); A review of intervention studies aimed at household energy conservation; *Journal of Environmental Psychology* 25 (2005) 273–291; Department of Psychology, University of Groningen.

Brundtland, G.H. (1987); *Our Common Future*. Oxford University Press, Oxford.

Calvillo Rubio C., Hoek T., Kempenaar W., Ochando Fons R., Vecht, van der H. (2012); *Restoration Sustainable Strawboard Factory*; B.Sc. thesis Building engineering, Hanze University of Applied Sciences Groningen and Universitat Politècnica de València.

DBF (2010); *Ontwerp Haalbaarheidsonderzoek infocentrum Strokarton in Oude Pekela*, mei 2011.

Jonge, de W. (2011); *Duurzaam verbeterd! Bepaling duurzaamheid herbestemming karakteristieke gebouwen*; 4 oktober 2011.

Leck, J. van der Zijlstra T., Smit M. and Sarsam K. (2012); *Herbestemming voormalig zuivelfabriek 'De Dongeradelen' te Lioessens*; June 6, 2012; B.Sc. thesis Building engineering, Hanze University of Applied Sciences Groningen.

Lysen, E. (1996); *The Trias Energica: Solar Energy Strategies for Developing Countries*; Eurosun Conference, Freiburg, 16-19 Sept 1996.

Ministerie van Volksgezondheid, Ruimtelijke Ordening en Milieu (VROM) (1988); *Monumentenwet 1988*; nummer BWBR0004471.

Nelissen N.J.M. Smits J., Bogie M.J.S. en Voorzee J. (1999); *Herbestemming van grote monumenten, een uitdaging!*; Drukkerij Bilbo b.v. 's Herhogenbosch; ISBN 90.70706.22.9.

Nusselder E.J., Ven, H. van der, Haas M. en Dulski B. (2008); *Handboek Duurzame Monumentenzorg*, Theorie en praktijk van duurzaam monumentenbeheer; SBR; Deckers Druk, Zwijndrecht (B) Rotterdam, september 2008; Artikelnummer 592a.08; ISBN13 978-90-5367-484-0.

O.O.M. (2011); *Toolkit Energy Sustainable Historic Buildings*; not published publicly.

Rijksdienst voor het Cultureel Erfgoed (RCE) (2009); *Erfgoed-balans 2009*. Archeologie, monumenten en cultuurlandschap in Nederland; Ministerie van onderwijs, cultuur en wetenschap (OCW); Amersfoort 2009; ISBN: 978.90.7604.662.4.

RCE (2010); *Een toekomst voor... ..boerderijen* (december 2010); *...molens* (oktober 2011); *...kerken*(juni 2011); *...watertorens* (januari 2013); *...kloosters* (januari 2013), a series on reuse of historic building types; Ministerie van onderwijs, cultuur en wetenschap (OCW); Amersfoort.

Roffel R. and Glas D. (2013); *Energieke restauratie 'Der Aa-kerk'*; B.Sc. thesis Building engineering, Hanze University of Applied Sciences Groningen.

Ven, van de H. (2011); *Duurzaam Erfgoed*; Rijksdienst voor het Cultureel Erfgoed (RCE); uitgeverij Terra Lannoo, Houten.

Vieeen M.C. (2012); *Monument herbestemt het buitengebied*, de invloed van overheidsbeleid op het herbestemmen van monumentale gebouwen in het buitengebied in de provincies Drenthe en Groningen; M.Sc. theses Spatial planning, University of Groningen; januari 2012.

Vieeen M.C. (2014); Urgency and motives for the modification of historic buildings; *Conference proceedings Energy efficient Restoration*; Hanze University of Applied Sciences Groningen.

## Pictures cases studies

BLG (2002); archive; figure 25 (November 2, 2002).

Calvillo Rubio C., Hoek T., Kempenaar W., Ochando Fons R., Vecht, van der H. (2012); Buildings observation; figure 8 (Februari 23, 2012); figure 16, 18, 19 (March 28, 2012); figure 20 (March 30, 2012); figure 15 (April 18, 2012), original source unknown.

Calvillo Rubio C., Hoek T., Kempenaar W., Ochando Fons R., Vecht, van der H. (2012); *Restoration Sustainable Strawboard Factory*; figure 21, 22, 23; June 4, 2012; B.Sc. thesis Building engineering, Hanze University of Applied Sciences Groningen and Universitat Politècnica de València.

GoogleEarth (2013); figure 20 (September 19, 2013).

Leck, J. van der Zijlstra T., Smit M. and Sarsam K. (2012); Buildings observarion; figure 7 (March 21, 2012).

Leck, J. van der Zijlstra T., Smit M. and Sarsam K. (2012); *Herbestemming voormalig zuivelfabriek 'De Dongeradelen' te Lioessens*; figure 4, 5, 10, 11, 12, 13, 14; June 6, 2012; B.Sc. thesis Building engineering, Hanze University of Applied Sciences Groningen.

Roffel R. and Glas D. (2013); *Energieke restauratie 'Der Aa-kerk'*; figure 29; June 6, 2012; B.Sc. thesis Building engineering, Hanze University of Applied Sciences Groningen.

Vieeen (2012-2013); Buildings observation; figure 6, 7, 8, 9 (March 29, 2012); figure 24, 26, 27, 28 (August 28, 2012); figure 17 (March 3, 2013).